Study of surface runoff generation and simulation of model on slope of red soil

Yang Jie[1] – Zuo Changing – Zhang Guohua

[1]Jiangxi Province Research Institute of Soil and Water Conservation,Nanchang, Jiangxi 330029,China.
Tel.: 861-0791-8300292; E-mail: zljyj@126.com

1. Abstract

Rule and characteristic of surface runoff was studied on the typical slope of red soil in jiangxi province by standard runoff plot method. Numerical model was established and simulated surface runoff on slope of red soil at plots in jiangxi province. The result shows that : 1. runoff is unequal every months and shows double peak value in a year. Runoff have two peak value in Apr~May and Aug. every year ; 2. runoff is increased by intensity of rainfall; 3. The various-depth runoff volumes for plot covered with Bahia grass(Plot A), plot mulched with Bahia grass (Plot B) and the contrasted soil-exposed plot (Plot C) are unequally with various disposal of surface runoff. Change of land surface is one of the important measure to control soil erosion and water loss. 4. Numerical modeling of runoff on slope was studied and it accords with fact. Error of Simulation modeling is less than 15%.

2. Introduction

Red soil is widely distribution in south China while red soil can be found everywhere in the 15 provinces and autonomous regions in south China. South China is deemed as a major region for production of tropical commercial crops and grain in China.

The research area is located within the boundaries of De'an County in northern Jiangxi Province, just at 115°42′east longitude and 29°17′north latitude. In the research area, the topographic type is low hills, with an elevation of 30-100 meters and a slope not more than 25°. It's typical red soil and a central area for red soil distribution in China. This area is situated within the subtropical monsoon climate zone, where the climate is warm, with plentiful rainfall. The many-year average rainfall is 1469mm. The major type of soil erosion is water erosion.
Rainfall is the cause and motivity of water erosion on red soil slope. Rainwater on the surface can be separated into three parts, one is infiltration, the others are evaporation and runoff. As dissolved nutrients in rainwater, runoff is the important carrier which transfers soil and nutrients. In order to realize soil and water losing process with runoff and forecast and control soil erosion and nutrients losing, it is very important in studying rule and character of rainwater and runoff.

3. Methods

Standard runoff plots of 5×20m in the test area just on the same slope, with an individual horizontal projected area of 100m^2 and a slope of 14°for all the plots. To prevent the surface runoff in the plots from inflow and outflow, the plots are specially enclosed with dykes. Dyke is 30cm high above the surface and rooted into the land by 45cm in depth. Below the plots, square water-containing troughs are constructed there to contain the runoff and sediment from the plots and then lead them into the runoff pool. With a design in full consideration of the maximum possible rainstorm volume and the maximum possible runoff in the local area, the runoff pool is composed of three square pools respectively named pool A, pool B and pool C, but all in the size of 1.0×1.2×1.2m. in addition, 60°and V-shape triangular diversion weirs are constructed on both walls of the Pool A and Pool B, about 0.74 meter distant from the bottom of the pool. Four portions of the runoff will be discharged out, but one portion neighboring Pool A will be discharged to Pool B. Similar as in Pool B, one portion in Pool B will be discharged to Pool C. Rating is conducted in all the pools and the pool wall is installed with an enamel water gauge, from the reading on which, we can calculate out the surface runoff. Whenever there is runoff, we take the runoff sample and dry it for measurement of the soil erosion. The test is carried out on 3 plots respectively known as grass-covered plot, grass-mulched plot and contrasted soil-exposed plot. Other methods adopted are fully in conformity with the requirements as specified in "Standard for Soil and Water Conservation Test".

4. Results

1character analysis of rainfall

According to 5 years measurement, there were 735 rainfall which sum up 7259mm during 2001~2005. Rainfall is unequally in a whole year though it is plentiful. That is listed in table 1-Statistics of the average rainfall distributing in 2001-2005. As shown in the results of Table 1, the rainfall is not equally every month in a whole year.

In a word, rainfall is all in Apr., May. , Jun., Jul. and Aug..

Table 1 Statistics of 5-year average rainfall distributing every month

month	1	2	3	4	5	6	7	8	9	10	11	12
2001	126.7	51.9	92.2	178.8	83.5	120.6	92.5	209.1	2.3	79.1	57.8	69.8
2002	53.1	32.1	129.0	378.0	385.5	86.5	191.1	166.9	90.2	81.3	91.4	123.4
2003	43.9	158.8	137.1	326.1	228.8	283.4	55.9	31.3	61.9	38.4	43.3	24.1
2004	64.4	60.4	51.8	120.9	281.5	164.0	135.4	298.0	21.4	0.9	73.6	30.1
2005	76.7	152.9	84.6	115.8	160.6	207.3	160.0	98.1	253.4	54.4	170.8	16.3
average	72.96	91.22	98.94	223.92	227.98	172.36	126.89	160.68	85.84	50.82	87.38	52.74

2 analysis of character on surface runoff

Distributing characteristic of runoff on red soil slope depends on rainfall in this zone. After the filed measurement, the result of runoff is listed in Table 2-statistics of 5-year average runoff distributing in every month. As shown in the results of Table 2, 5-year average surface runoff depth is mainly distributed from Apr. to Aug. . It is 86.66mm on Apr., 76.97mm on May. , 54.15mm on Jun. , 33.07mm on Jul. and 44.93mm on Aug. . surface runoff of these month accounts for 75% of the total. That is one of reason why soil erosion and water loss are serious in this area.

Table 2 Statistics of 5-year average runoff distributing in every month

Month	1	2	3	4	5	6	7	8	9	10	11	12
Average rainfall(mm)	72.96	91.22	98.94	223.92	227.98	172.36	126.98	160.68	85.84	50.82	87.38	52.74
Average runoff depth （mm）	5.508	13.692	21.832	86.664	76.972	54.156	33.076	44.9328	25.274	4.16	18.898	8.894

3 analysis of different surface covered effect on runoff

According to measurement, the various-depth runoff volumes for plot covered with Bahia grass(Plot A), plot mulched with Bahia grass (Plot B) and the contrasted soil-exposed plot (Plot C) are listed in Table 3-Statistics of surface runoff with various disposal. As shown in the results of Table 3, the surface runoff volumes keep a order of A < B < C, indicating that the plot covered with Bahia grass is of better effect in soil and water conservation compared with that mulched with Bahia grass. Whilst, the runoff volume in the contrasted soil-exposed plot is much more than that in Plot A or Plot B. It's obvious that lands covered or mulched with grass are of good effect in soil and water conservation.

Table 3 Statistics of surface runoff with various disposal

Serial number	year	rainfall （mm）	Surface runoff（mm）		
			Covered with Bahia grass (Plot A)	Mulched with Bahia grass (Plot B)	Contrasted soil-exposed (plot C)
1	2001	1164.3	18.58	31.11	224.49
2	2002	1808.50	22.41	46.83	538.31
3	2003	1433.00	18.18	26.07	435.77
4	2004	1302.40	20.46	23.20	404.30
5	2005	1550.90	24.53	30.45	367.43
6	total	6094.80	104.16	157.65	1970.30

4 numerical modeling simulations of surface runoff

The surface runoff plays a dominant part in soil erosion during rainfalls. The approach of simplified kinematic wave modeling is applied to surface runoff simulations. The model-simulated results agree well with the experimental observations. Applying the model to the practical case of plots, the simulated results adequately reflected the surface runoff, which error is less than 15%.

Table 4 Comparative analysis on observed and simulated of surface runoff

date	Covered with Bahia grass			Mulched with Bahia grass			Contrasted soil-exposed		
	observed/mm	simulated/mm	error/%	observed /mm	simulated/mm	error/%	observed /mm	simulated/mm	error/%
2004.3.20	0.21	0.23	11.33	0.24	0.25	5.93	3.35	3.85	14.81
2004.6.18	0.34	0.38	13.10	0.37	0.39	5.61	8.58	9.12	6.29
2004.2.28	0.38	0.43	11.98	0.49	0.55	11.20	3.19	2.89	-9.37
2004.5.7	0.72	0.69	-3.63	0.76	0.79	3.58	10.03	9.89	-1.40
2004.5.3	0.48	0.42	-12.01	0.65	0.72	10.43	32.17	33.54	4.27
2004.6.23	0.94	0.88	-6.77	1.08	0.95	-11.71	15.16	14.36	-5.26
2004.7.31	0.06	0.07	14.19	0.08	0.07	-12.50	5.70	6.1	7.09
2004.8.1	0.29	0.26	-9.66	0.27	0.29	8.21	6.54	5.98	-8.61

5. References

［1］ Woolhiser D A, Liggett J A. Unsteady, one-dimensional flow over a plane- The rising hydrograph. Water Res Res, 1967, 3(3):753-771.

［2］Singh V P. Kinematic Wave Modeling in Water Resources: Surface Water Hydrology. New York: John Wiley & Sons, 1996

［3］ Singh V P. Kinematic Wave Modeling in Water Resources: Environmental Hydrology. New York: John Wiley & Sons, 1997.